It may therefore be hoped that in the near future an understanding will be arrived at on the importance of the development to be given to the observatory of the Azores, and I ask the Royal Society, whose influence is so great in the domain of science, to support, by its concurrence, the accession of England to the ideas which I uphold for the common interest.

"A Compensated Interference Dilatometer." By A. E. TUTTON, Assoc. R.C.S. Communicated by Captain ABNEY, C.B., F.R.S.

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(Abstract.)

The author describes a form of Fizeau interference dilatometer which he considers combines the best features of the apparatus described by Benoit, and belonging to the Bureau International des Poids et Mesures, in Paris,* and that described by Pulfrich'† constructed according to the modifications introduced into the method by Abbe. Moreover, besides other improvements, a new principle, that of compensation for the expansion of the screws of the Fizeau tripod which supports the object, is introduced, which enhances the sensitiveness of the method so highly as to render it applicable to the determination of the expansion of crystals in general, including those of chemical preparations. Hitherto the application of the Fizeau method has been confined to such crystals as could be obtained large enough to furnish a homogeneous block at least a centimetre thick. A block only 5 mm. thick is ample for use with the author's compensated dilatometer. The principle of the compensation depends upon the fact that aluminium expands 2·6 times as much as platinum-iridium for the same increment of temperature. The author therefore employs, like Fizeau and Benoit, a tripod of platinum-iridium, and places upon its transverse table, through which pass the three screws, a disc of aluminium whose thickness is 1/2·6ths of the length of the screws. The space between the lower surface of the glass plate which is laid upon the upper ends of the screws to assist in producing the interference, and the upper surface of the aluminium, then remains constant for all temperatures under observation, and if a crystal is laid upon the aluminium compensator the whole amount of its expansion by rise of temperature is available for measurement by the interference method. Hence the method is no longer a merely relative one, affording the difference of expansion between the tripod and the substance investigated, but affords directly absolute measurements of the expansion.

* 'Trav. et Mémoires,' 1881, p. 1.

† 'Zeits. für Instrumen.,' 1893, p. 365.

The instrument consists of two independently mounted portions, which the author terms respectively the expansion apparatus and the illuminating and observing apparatus. For the purposes of preliminary adjustment the two portions are arranged at close quarters, while during the observations they stand at opposite ends of the slate table, 6 feet in length, upon which they are mounted, the expansion apparatus resting on a separate and movable cloth-lined slab for the purpose of effecting the transfer from one position to the other. Hence the optical measuring apparatus is far removed during observations from the heated atmosphere of the chamber containing the tripod.

The illuminating and observing apparatus consists of a telescope arranged with a side tube for auto-collimation. It is mounted on a stout pedestal provided with three legs and levelling screws, and its height can be varied by the vertical rack and pinion movement of a stout inner column. At the common focus of the lens of the side tube and of the telescope objective a small totally-reflecting prism is placed, half closing the aperture of a diaphragm placed on the objective side of the prism in the main optical tube; the prism is so arranged that the light from the illuminating lens is reflected through the diaphragm to the objective. It passes thence, as parallel rays, across the intervening space to the expansion apparatus, at the summit of which it meets with one of two interchangeable deflecting arrangements which direct the rays vertically down the tube of the expansion apparatus into the interference chamber containing the tripod. One of the two is a large totally-reflecting prism ; this is used when white light or a sodium flame is the source of light placed before the illuminating lens, the former for adjusting purposes and the latter for generating the bands. The other is a train of two refracting prisms whose total minimum deviation averages 90°; this is used when a hydrogen and mercury Geissler tube is the source of light; the dispersion being then adequate to effectively separate the red C from the greenish-blue F radiations, or both from the mercury green radiation, when it is desired to generate bands in C or F hydrogen light, or that corresponding to the green mercury line as recommended by Pulfrich.

The expansion apparatus is suspended from an arm carried by a pedestal provided with rack and pinion vertical adjustment as in the case of the observing apparatus. Below the deflecting prism or prisms the short metal tube passes into a longer one of porcelain, which at its lower end is fitted into a further short metal tube carrying below the interference chamber within which the tripod is placed. On passing down the tube from the deflecting apparatus the rays pass first through a slightly tilted, thick glass disc held in a diaphragm and forming the roof of the interference chamber. They

then pass through the large cover-disc laid on the tripod screws, the under surface of which is one of the two surfaces the reflections from which are to be made to interfere; the other of the two relevant surfaces is the upper surface of the crystal supported on the compensator, or in the case of a badly reflecting crystal, of a small disc of black glass, polished above and ground below, which the author lays upon it. The large cover-disc and the glass roof-disc are slightly wedge-shaped to the extent of 35′, and are arranged complementarily so as to counteract the dispersion produced by each other; by using a wedge-shaped cover-disc the undesired reflection from the upper surface can be deflected out of the field of the telescope, and the tilt of the roof-wedge is given for a similar reason. After reflection from the two surfaces relevant to the interference, the rays re-traverse their path, but instead of doing so absolutely are made to pass through the clear half of the telescope diaphragm to the observing lens arrangement. An iris diaphragm is placed against the main diaphragm to assist in further excluding undesirable radiations, and the illuminated surface of the small reflecting prism can be more or less curtailed by suitable rectangular signal-stops.

There are two observing lens arrangements: one a simple eyepiece and the other a micrometer combination of three lenses. The first enables the observer to properly adjust the images of the signal stop in white light reflected from the two relevant surfaces of the interference apparatus, so as to cover each other to the extent required to produce interference bands of requisite width. The micrometer combination converts the observing apparatus into a microscope wherewith to view the bands. The spider-lines of the micrometer are simultaneously visible. The reference point of the interference apparatus is the centre of a minute silver ring on the under surface of the cover-wedge, and the two vertical spider-lines can be adjusted by a special drum to such a separation as enables the inner circle of the ring to be brought symmetrical to them, showing equal suitable arcs outside each; this separation is also convenient for the width of band generally employed, which corresponds to 100 drum divisions of the other drum which moves both spider-lines simultaneously.

The interference chamber is provided with an adjusting table of non-conducting material, and is quite open to the heated air of the bath, being provided with large windows, which are also very useful for the adjustment of the tripod. The heating bath is a double air bath of copper suitably screened in every direction by asbestos millboard. It is provided with a thermostat in the outer bath and two thermometers in the inner bath. The expansion apparatus is immersed in the latter up to a third of the porcelain tube. The actual temperature of the tripod is ascertained by a third thermo-

meter, bent so that the bulb lies within the chamber in contact with the tripod itself; this has been found to be a point of the first importance. With the aid of the thermostat and a graduated gas tap a constant temperature can readily be attained.

The author determines the position of the bands at about 10° C., again near 70°, and once more about 120°, in order that not only the mean coefficient, but the absolute coefficient at any temperature and the increment per degree may be ascertained. The transit of each band is followed and recorded permanently by means of a specially constructed tape-puncturing recorder. This method is found more satisfactory than relying exclusively on the Abbe method of mere observation of the initial and final positions of the bands for light of two wave-lengths.

The results of numerous determinations of the expansion of the platinum-iridium of the tripod are given, carried out with the surface of the tripod table and the cover-wedge separated at the long interval of 12 mm., by the aid of green mercury light. The mean value is very similar to that of Benoit, and is

$$\alpha = 10^{-9}(8600 + 4{\cdot}56t).$$

The result of several determinations in red hydrogen light of the expansion of the pure aluminium used for the series of compensators, carried out by the Fizeau relative method with a block 12 mm. thick, is

$$\alpha = 10^{-8}(2204 + 2{\cdot}12t).$$

Similar determinations for the black glass of the crystal-covering plates afford the value:

$$\alpha = 10^{-9}(7257 + 10{\cdot}4t).$$

In a subsequent memoir the author intends to present the results of determinations of the expansion of the sulphates and selenates of potassium, rubidium, and cæsium.